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学 位 論 文 審 査 の 要 旨

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学 位 論 文 題 名

Studies on land-use/land-cover change and forest fragmentation with the implications
for landslide occurrence in the Garhwal Himalaya, India

(インド, ガルワール・ヒマラヤにおける土地利用・土地被覆変化および地すべり発生と関連した森林の分断化に関する研究)

The Himalayan region including the Garhwal Himalaya is believed to have experienced extensive deforestation and forest fragmentation, but data and documentation detailing this transformation are limited. Forest fragmentation has been believed to cause landslides. However, previous studies have examined forest fragmentation and landslide occurrence separately. Therefore, understanding their link is important in the mountains such as the Himalaya. This study used satellite remote sensing and geographic information system (GIS) to create a spatial inventory of land-use and land-cover (LULC), and to examine forest fragmentation and landslides in the Garhwal Himalaya. Then, an evaluation on how potential change of forest fragmentation would result in changes of landslide susceptibility and vice versa. Three images from Landsat (1976, 1998, and 2014) were used to extract land cover. A cross-tabulation detection method in a GIS module was used to understand land cover changes during the 1st period (1976–1998) and 2nd period (1998–2014). The landscape fragmentation tool LFT v2.0 was used to prepare a forest fragmentation map and to analyze the patterns and changes of the forest fragmentation during the two periods. Using the weight-of-evidence (WOE) model, the relationship between the forest fragmentation and the landslide occurrence was established to identify the potential change of forest fragmentation and landslide susceptibility.

The results showed that the overall annual rate of decreasing change in the forest cover was 0.22% and 0.27% in the 1st period (1976–1998) and 2nd period (1998–2014), respectively. Non-forest area, i.e., agriculture land, built-up area, scrub land and barren land, had increased in both periods of time. The forest fragmentation analysis showed that a large core forest has decreased throughout the study period. The increased non-forest and perforated areas were the main cause of the decline in the large core

forest. The total area of the forest patches also increased during the entire study period.

The result of the weighted contrast value showed that the forest fragmentation probability was primarily observed near built-up area (<500 m), agriculture land (<500 m), roads (<1000 m), and streams (<500 m) with very gentle and gentle slopes (<25 degree) at the lower to middle altitude zone (<2000 m). The probability map of the forest fragmentation showed that medium to high probabilities are primarily concentrated near the roads and agriculture land area on very gentle to gentle slopes at the lower altitudes. The probability map of the forest fragmentation also showed that the role of higher altitude zone (>2000 m) is less significant. The result suggested that the area would experience more forest fragmentation in the future due to the increased area of patch and perforated forests, meaning the increase in the forest degradation. Regarding the landslide susceptibility, the result clearly showed that medium to high landslide susceptibilities had occurred mainly in the non-forest area. The result of the weighted contrast value showed that most medium to high landslide susceptibilities are primarily concentrated in the areas adjacent to higher altitudes, steep slopes, and the non-forest area such as scrub land, barren land, and pasture land. The forest fragmentation probability was observed in the areas where landslides are less likely to occur. The probability of landslides would not give a major influence on forest fragmentation and vice versa, which was suggested for the first time by the approach with the combination of both forest fragmentation and landslide occurrence.

The examination committee recognized that this thesis would contribute to the better management of forests in the lower altitudes of the study area particularly, and to the discipline of land science in mountain regions, which helps in future conservation and management of forests and resultant life of mountain people. The committee evaluated enthusiasm of the applicant in intensive, time-consuming laboratory work together with field survey, and for collaboration with many students during the course of graduate school, thereby concluded that the applicant is eligible for the degree of Doctor of Philosophy (Environmental Science).